# Bioclimatic zoning of moringa (Moringa oleifera Lam.) in the Iberian Peninsula for biofuels.

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## INTRODUCTION AND OBJECTIVES

The world energy consumption has increased in recent years, particularly in those regions undergoing a rapid development. Traditional energy supply from fossil fuel sources presents mainly two troubles: these sources are finite, and their impact on the environment is high. These circumstances require the development of alternative sources of energy, among which we propose to include biomass for energy.

Moringa oleifera (MO) is a tree native from the southwest of the Himalayas, that from ancient has spread through southern Asia and Africa. With the Nao de Manila, this plant was introduced in America, where it has recently spread widely across the continent, from southern U.S. to northern Chile and Argentina. In Spain, this plant is starting to be cultivated in the subtropical zones of the peninsula and also in the Canary Islands.

Its multiple uses make MO an attractive crop in different fields of human or animal feeding, cosmetic and pharmaceuticals. As a producer of biofuels, MO seeds provide an oil that may be easily transformed into biodiesel, and its leaves, peels and pods may be used to produce bioethanol. According Foild, a ton of MO fresh biomass can produce over 34 l of bioethanol, that is, about 20.000 l of ethanol/ha/year when using high densities of plantation (one million plants per ha).

The objective of this study is to define MO bioclimate, considering the different climatic variables that limit the development of existing biotypes, and last, to map feasible implantation sites in the Iberian Peninsula.

## MATERIALS AND METHODS

There is no much scientific information about MO, and this fact restricts the possibility of further studies. We are aware that if we had had more information about this species our study would have been achieved with greater accuracy, however, our work is presented below.

First, information on climate data that determine MO natural and artificial distribution, is collected:

- Frost is a factor that excludes the existence of MO. Average temperature of the minimum values below -1 ºC has been considered during December, January and February.
- MO does not survive when temperature rises above 48 ºC. This factor is applied to the summer months.
- If monthly average temperature (AT) > 8 ºC during winter months, the risk of frosts is low, so the plant can survive, but does not grow unless AT > 13 ºC.
- If AT > 13 ºC during autumn and spring, the plant is able just to develop.
- When AT is between 25 ºC and 35 ºC, plant growth and production of pods and leaves are both optimized.
- As for precipitation, MO does tolerate drought; it requires 500 mm per year, but is able to survive with about 300 mm.

Second, we asked from AEMET data of the Climatic Atlas of the Iberian Peninsula and Balearic Islands.

Third, we elaborated temperature and precipitation maps, considering the climatic requirements of MO according to the references we had. For data analysis, the software we used was ArcMap application of 9.3 ARGIS.

## DISCUSSION

Overlapping maps made with climatic factors limiting the distribution of this species, zones "SUITABLE for growing MO" are obtained.

If the optimum growth constraint is added, (AT over 25 ºC), then we can know the regions where cultivation of the plant has a greater economic potential: map of "BEST areas for MO cultivation". This map is very similar to the above-cited, and it is important to see that in Portugal productivity may be lower than in the rest of the Iberian Peninsula.

Studying the behavior of the variable AT > 13 ºC in autumn and spring (Fig. 8 and 9), we may estimate the areas where the sowing should be performed more or less in advance. This fact, together with the delay in the arrival of cold weather, will allow the farmer to obtain more or less crops, when cultivating MO for green food.

## CONCLUSIONS

Growing MO can result highly profitable when using it for biofuels, especially bioethanol.

MO main limitations are the risk of frost and extreme aridity. Attending to temperature, MO can be a plant of great interest to be cultivated in the southern regions of the peninsula: the lower valleys of the Guadalquivir, Guadiana and Tajo, and the Mediterranean coast. MO can be influenced by the proximity to the Atlantic coast.

This plant will need watering close to the Mediterranean coast, and in some dry zones inside the valleys of the Guadalquivir and Guadiana. In zones considered as BEST, irrigation is necessary only in the early stages. As a tree, MO can be a source of biodiesel, and in degraded land can be used to avoid losses of soil, and for restoring landscapes.

When used to produce green biomass for ethanol, MO will need watering.

## RESULTS

Maps resulting of compounding the weather data from the Iberian Peninsula, with the specific constraints of MO as regards climate and precipitation:

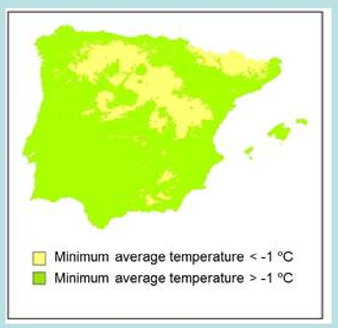



Fig 1: Monthly average temperature of the minimum values above -1 ºC in winter


Fig 2: Average temperature of the coldest month between 0 ºC and 18 ºC

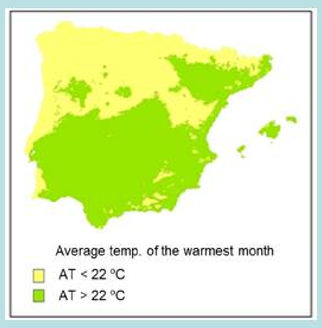



Fig 3: Average temperature of the warmest month above 22 ºC


Fig 4: Average temperature above 8 ºC in winter


Fig 5: Average annual temperature above 13 ºC

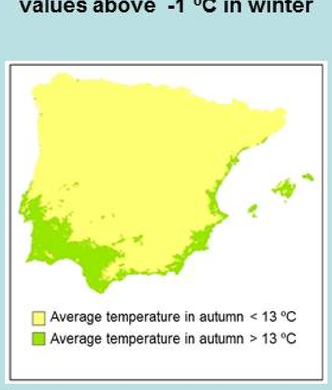



Fig 6: Average temperature above 13 ºC in autumn

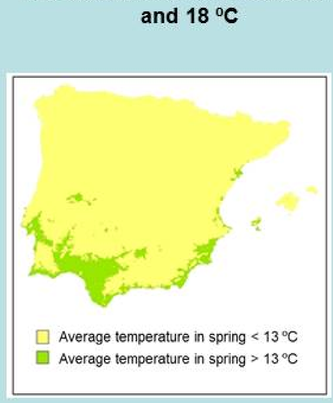



Fig 7: Average temperature above 13 ºC in spring

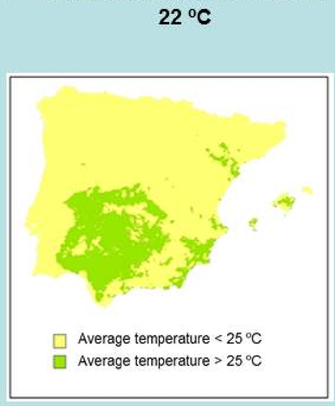
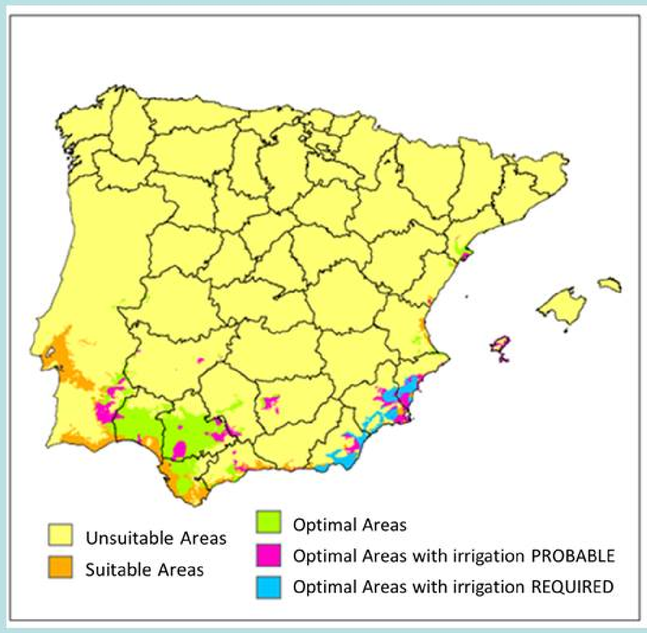



Fig 8: Average temperature above 25 ºC in July and august


Fig 9: Rainfall above 300 mm


Fig 10: Rainfall above 500 mm




**BEST and SUITABLE areas for growing *Moringa oleifera* Lam.**

## BIBLIOGRAPHY

AGENCIA ESTATAL DE METEOROLOGÍA (AEMET). 2011. Atlas climático ibérico. Ed. Ministerio de Medio Ambiente y Rural y Marino, 79 pp.

ARIAS SABÍN, Consuelo. 2014. Estudio de las posibles zonas de introducción de la Moringa oleífera Lam. en la Península Ibérica, Islas Baleares e Islas Canarias. Proyecto Fin de Carrera/Grado: E.U.I.T. Forestal (U.P.M.) Madrid.

FALASCA, S.; BERNABÉ, M.A. 2008. Potenciales usos y delimitación del área de cultivo *de Moringa oleifera* en Argentina. Redesma.

FOILD,N.; MAKKAR, H.P.S.; BECKER,K. 2001. The potential of *Moringa oleifera* for agricultural and industrial uses. In: Procedings of International Workshop What developement potential for Moringa products. Oct 29th to Nov 2nd. Dar Es Salaam, Tanzania.

PÉREZ, C. 2012. *Moringa oleifera* Lam., especie forestal de usos múltiples. Revisión bibliográfica. Trabajo de Fin de Carrera: E.U.I.T. Forestal (U.P.M.) Madrid.